Personalized Health, eLearning, and mHealth Interventions to Improve Nutritional Status

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Abstract (117 words, Limit=150 words)

Personalised health through nutrition has been made possible by recent advances in technology. We ran a search strategy in July 2016 to identify all existing studies on mobile/eLearning randomized controlled interventions designed to improve diet, nutrition and/or body weight in adults, at individual or community level. A total of 22 studies met the inclusion and exclusion criteria for inclusion. Most studies found that Integrations of technology for delivering and personalizing interventions on diet/nutrition and/or body weight were effective in reducing body-weight in overweight/obese populations (n=8), preventing weight-gain n=4) and improving certain dietary habits (n=10). The low cost of ehealth/mHealth interventions, and their potential to reach large, sometimes hard-to-reach, young population sectors makes them attractive targets for upscaling.

Introduction

Non Communicable Diseases (NCDs) account for 16 million premature deaths per year around the world[1]. Leading causes of premature death which also underpin the development of NCDs are poor dietary habits and excessive body weight[2]. Addressing those two major public health problems is a critical step towards controlling and sustaining the prevalence of NCDs and premature death in both developing and developed countries. Lifestyle advice aiming to modify risk factors for the development of NCDs is the cornerstone of both treatment and prevention of NCDs. Increasing access to internet services and mobile devices such as tablets and smartphones changed drastically the landscape for delivering public health and healthcare interventions[3].

Personalised medicine, health and nutrition are terms that first appeared in the 70s but it is only the past few years that they've started becoming more popular[4]. Even though, the terms of personalised medicine, health and nutrition are often considered only in the context of interactions between genes and lifestyle, technology made possible a new level of personalization. Technology offers new ways of communication and multiple features that technology-based interventions can take advantage of[5] and tailor interventions to participants' lifestyle 'phenotypes'. Different capabilities and features of each of the modalities used in interventions, how these might work with personalizing nutrition and health and their effectiveness are still not clear. In the present study, we reviewed the rapidly growing body of literature by conducting a systematic review of the highest-quality published studies relating primarily to personalized diet with mobile technology. The purpose of this systematic review is to evaluate the evidence of the effects of interventions using mobile devices on nutrition and body weight outcomes in all settings across all countries in adult population (over 18 years old) in randomized controlled trials.

Methods

For this review, we use the definition of Sangra and colleagues[6], of which the most relevant three are:

(1) e-learning is an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools

for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning".

(2) ehealth refers to the use of internet and other information technologies for the diagnosis, treatment or prevention of disease or public health[7].

(3) mhealth is a segment of eHealth covering the diagnosis, treatment or prevention of disease or public health using mobile devices such as tablets, smart phones, Personal Digital Assistants (PDAs) and smart watches[8]

Data Sources and Search Strategy

A search strategy was devised and carried out electronically in July 2016. The electronic databases searched were CINAHL, PubMed, EMBASE, MEDLINE, and PsycINFO. These databases were searched for studies conducted between January 2000 and July 2016. The search was limited to English-language publications. The following text-word and MeSH terms were used: nutrition, mobile, eLearning, online, diet, personalized/personalized, weight.

Article Selection

Search results yielded through the search strategy were imported into the citation management software EndNote for screening and aggregation of the research articles relevant for this review Two researchers reviewed all article titles and abstracts identified from the electronic searches and grouped them in respective folders; excluded-not eLearning/mobile learning, excluded-not diet related, included, and unsure. The full-text of the articles in the included folder were then further assessed for inclusion against the inclusion and exclusion criteria set for this review. Any disagreements between researchers for the appropriateness for inclusion of any article were resolved through discussing individual study characteristics against the inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

The criteria for inclusion were; randomized trials, using a mobile device or internet to deliver an intervention which would have as a primary outcome nutrition or body weight in adults (over 18 years old). Exclusion criteria were; non-randomised trials (cohort, observational, case-control), studies conducted in children, and studies having as primary outcome non

dietary outcomes such as HbA1c, cholesterol levels, blood pressure etc. Some of the definitions of the terms and technologies considered in this review are reported here.

Outcome Measures

Included studies had to report as primary outcome either a nutrition/dietary outcome or body weight (macro- and micro-nutrients consumption, food consumption, overweight/obesity). Studies could have as a target disease treatment, disease prevention or health promotion either at individual-level or at community level.

Assessment of Study Quality

The quality of each of the included studies was assessed using the Cochrane's Collaboration Risk of Bias Tool and GRADE tool[9]. Studies of very low quality were excluded.

Data Extraction

Data on study characteristics and results of primary and secondary outcomes were extracted from the included studies. A table was created with the main characteristics of each study; year of publication, number of participants in intervention and control groups, research question, primary outcome, disease addressed, age of participants, technology used, study duration. Results on the assessment of the quality of each study based on the assessment of risk of bias and GRADE tool were also added in the same table.

Results

Search Strategy and Included Studies

The search strategy through the databases yielded 659 titles potentially relevant for inclusion in this review. A total of 633 studies were excluded after a screening of titles and abstracts, because they were not addressing research questions relevant to this review or they were not randomized trials (97). For the remaining 26 studies, full text articles were retrieved and assessed against the inclusion and exclusion criteria. A total of 22 publications met the inclusion and exclusion criteria, and had data extracted from and were also assessed for quality against the Cochrane criteria for randomized controlled trials. Figure 1 provides the flow diagram illustrating results and screening process.

Key Characteristics of Included Studies

After assessment against inclusion and exclusion criteria and study quality, a total of 22 publications were found to be eligible to be included in this review[10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31]. The 22 publications described 21 studies, all conducted in high-income countries. Nine were conducted in the United States, seven in Australia, two in South Korea, one in the Netherlands, one in Israel and one in UK. A total of 9,458 participants were included in all 21 studies, among whom 6,069 received either an eHealth or an mHealth intervention, with 3,389 participants in the control groups. Publication years ranged from 2010 to 2016, with 14/21 studies published between 2014 and 2016. The mean age of participants in the intervention groups was 36.7 years ranging from 20.4-63.0 years. The mean age of participants in the control group was 38.8 years ranging from 19.6-57.7 years.

The studies used a variety of mediums for delivery of both the eHealth and mHealth interventions. Ten studies contained interventions involving smartphone apps, for six of which the app was the sole component of the intervention. The other four studies involved an app in a multi-component intervention. Six studies involved a website component to the intervention, three used a Personal Digital Assistant (PDA), three utilised emails in the intervention, two studies contained interventions with basic mobile phones and the use of text messages, one study contained mobile phone with a multimedia messaging intervention. A total of 14 of the studies stated the intervention was theory-based [10,11,12, 13, 15, 16, 17,20, 21,25, 26, 28, 29, 30]. The theory most commonly applied was the Trans-theoretical model of health behaviour change[32] followed by the social cognitive theory[33]. The remaining eight studies made no reference to the use of theory in the intervention design.

Weight-Gain Prevention studies

A total of four publications[10,11,12,13] describing three interventions aimed at the prevention of weight-gain in adults. Main study characteristics are presented in Table 1. Allman-Farinelli and colleagues[10] randomized 250 young adults into two groups with equal numbers. The intervention group (n=125) received an mHealth programme consisting of five coaching calls, eight personalized text messages per week, a diet and nutrition booklet, and access to a

website which contained four designer apps for education on four key lifestyle behaviours; high-fat, high-energy take-out meals, sugar sweetened beverages, fruit and vegetable intake and 60 min of physical activity. The control group received four text messages on the four key lifestyle behavior and were given a two-page handout based on the Australian dietary and physical activity guidelines. The intervention period run for 12 weeks followed by a 5-month maintenance period. The intervention group lost 3.7 kg while the control group lost 0.80kg. Partridge end colleagues[11] described the same study, but reported weight-changes at three months with the intervention before the weight maintenance period started. Participants in the intervention group and control groups lost 2.20kg and 0.20kg, respectively, significantly different between groups ($p<0.001$).

Lombard and colleagues[12] in 2010 conducted a cluster randomized trial with women who had at least one young child in elementary school. The intervention group (n=127) received advice though attending four interactive group sessions on health messages, behavior change and group discussions along with monthly text messages for 12 months. The control group (n=123) received standard advice though attending one non-interactive information session. After 12 months, the control group gained 0.83kg ($p<0.05$) while in the intervention group there was no difference in weight (-0.20kg).

Nikolaou and colleagues[13*] randomised over 20,000 young adults, age 18-24, and mean BMI 22.3kg/m^2 in a pragmatic 3-arm parallel-group trial. Two separate interventions were developed and tested against an un-intervened control group. One 'rational' intervention openly discussed the issues around calorie-control and weight-gain. The other 'Stealth' intervention directed participants towards calorie control covertly, by focusing on environmental and social issues around relevant foods. Both interventions resulted in weight-gain prevention. Participants randomized to the Rational intervention (n=1,810) lost 1.0kg and those with the Stealth intervention two (n=2,134) lost 1.35kg after 9 months of intervention. Over the same period, participants in the control group gained 2.0kg which is close to the average weight gain observed in young adults[34,35] . Differences were significant among groups ($p<0.001$).

Each of the studies used different technologies. Allman-Farineli used a combination of text messages, website, apps, and emails, Lombard used only text messages and Nikolaou used the Moodle website along with weekly emails. All studies aimed at preventing weight-gain but only the study by Nikolaou and colleagues recruited normal weight subjects (BMI= 18.5-24.9kg/m^2) while the others recruited overweight subjects (BMI>25.0kg/m^2).

Weight-Loss studies

Out of the 22 publications identified in this review, eight publications[14,15,16,17,18,19,20,21] describing eight studies had as their primary outcome weight-loss in overweight and/or obese populations. The main characteristics and study quality of these studies are presented in Table 2. Study duration ranged from 2 to 24 months. A variety of technologies were used, as in the weight-gain prevention studies. Mobile applications were the sole intervention component in three studies. Brindal[14] used a mobile application to support women starting a meal replacement programme. The intervention group participants lost 3.8% of their body weight while the control group participants lost 2.5% of their body weight at 8 weeks. The difference in weight loss was significant among groups (p=0.024). The Uhealth app/service was used in a study with obese patients with metabolic syndrome[17]. The intervention group participants lost 2.21kg while the control group that received the standard care lost 0.77kg at 6 months (p=0.001). Wharton[21*] used a commercially available app 'Lose it' in overweight/obese individuals. The small intervention group (n=19) which used the app was compared with a second intervention group which used smartphones' memo to record dietary intake (n=18) and a control group which used paper and pencil to record the same. Participants in all groups lost weight and that was significant to the baseline weight (p=0.001) but there was no significant difference between the groups. The rest of the studies used either a combination of technologies to deliver their interventions or other single components. Text messages in addition to the standard care were used by Lin et al[16] for an intervention group who lost 5.2kg, while the control group lost 1.8kg, over 6 months. Text messages along with access to mobile apps, internet forums and emails used by Hebden et al[15] Intervention group lost 1.61kg while control group lost 1.41kg at 3 months with weight change not being significantly different between groups. Daily text messages and individual feedback through emails resulted in a weight loss of 1.27kg at 6 months in the intervention group while the control group gained 1.14kg in the same period in the study by Steinberg et

al[19] but difference was not statistically significant (p=0.09). Spring et al[18] used a PDA for the recording of diet, physical activity, and body weight in obese participants. The intervention group lost 3.9kg more compared to the control group at 12 months. Social Media (Twitter) in combination with podcasts and mobile apps were used by Turner-Mcgrieve et al[20] in obese individuals. The control group received only the podcasts. Both groups lost exactly the same percentage of body weight at 6 months (-2.7%).

Dietary Habits studies

Out of the 22 publications identified in this review, ten publications[22,23,24,25,26,27,28,29,30,31] had as primary outcome to improve dietary habits (macro- and micro-nutrients intake). The main characteristics of these studies are presented in Table 3. Duration of the studies ranged from one month to nine months. Text messages were used in two of the nine studies. Biweekly text messages for seven weeks resulted in greater fruit consumption and greater 'MyPlate' food recognition in the intervention group in the study of Brown and colleagues[25]. Weekly text messages for 6 months and feedback resulted in no significant changes in the number of servings from different food groups in the intervention group participants in the study by Kerr et al[28]. The remaining eight publications used mobile applications or websites to deliver the intervention, and most resulted in improvement of the dietary behavior in question (7/8). Ahn and colleagues[22] used a mobile app with a diet recording function using photos of the food for patients with type 2 diabetes, which resulted in increased healthful dietary behavior ($p<0.01$) and dietary attitude ($p<0.05$) in the intervention participants. Ambeba et al[23] provided tailored feedback through a PDA to participants trying to lose weight. At the end of the trial (at 24 months), the intervention group reduced their energy intake by 23.4% and saturated fat intake by 14.1% while control group reduced energy intake by 9.3% and saturated fat intake by 3.4%. Both were statistically significant; energy intake, p=0.03, saturated fat intake, p=0.04). Duncan et al[26] in male adults carried out an IT-based intervention aiming to improve dietary behavior and physical activity. At nine months there was no significant difference between groups. Mummah et al[28] in small study with eight participants in the intervention group and seven in the control group used a mobile app (Vegethon) for goal setting and tracking vegetable consumption. The intervention group had higher consumption of vegetables at 6 months compared to control group (13.5 vs 3.9 servings), $p<0.05$. Safran et al[29] set goals and provided feedback to healthy adults through a

web-based application. Diet quality improved in the intervention group while there was no change in the control group ($p<0.001$). A web-based planning tool was used in overweight adults for 4 weeks by Soureti et al[31] which resulted in lower consumption of high fat foods in the intervention group only. Lastly, Blackburne et al[24] used a digital game in his intervention which had as an aim to increase healthy food consumption. Participants were asked to play approximately ten short games lasting only a minute each for 2 weeks, then had a 4.5-week break and played the games again for another 2 weeks. By the end of this 2- month period, intervention group showed improved inhibitory control performance towards healthy food consumption.

Discussion

With diet and body weight being the most important modifiable factors implicated in the development of NCDs, exploring ways to treat and prevent overweight/obesity and improve dietary habits is critical. This systematic review offers evidence on how eHealth and mhealth technology is integrated into the delivery of public health and health care interventions for the prevention and management of overweight/obesity and improvement of dietary habits and personalizing of the interventions. The studies described in this review varied greatly in numbers and statistical analyses, as well as in the detailed intervention contents, but the great majority of the publications found significant weight-gain prevention, weight-loss and improvements in dietary habits, compared to the control groups. Also most of the included studies were of moderated or high quality. Only three studies were of low quality and those were downgraded due to due to the risk of bias during the randomization procedures and due to imprecision.

ehealth and mHealth sectors are growing rapidly in both developing and developed countries. eHealth offers a broad and easy access to services and has the potential to reach all the 1.9 million people currently overweight or obese[36] along with the rest of the population in need for advice on the prevention of overweight, obesity and NCDs. Mobile phone penetration currently stands at 62% and is expected to reach approximately 70% by 2019, globally[37] with the average time spent on a mobile device ranging from 101-840 minutes[38]. There are currently more than 100,000 health apps available in all app stores and a quarter is on weight-management[39]. In the studies included in this review that included mobile apps, those were

developed specifically for the intervention. Only one study used a commercially available app. The studies that used the apps developed specifically for the intervention all resulted in weight-loss and/or diet improvement while the study that used the commercially available app did not result in weight-loss which was the study's primary objective even though there was an improvement in the diet quality of the participants. Mobile apps and linkage with data from wearable devices offer a great opportunity for further personalization of nutrition but safety, quality of the information and accuracy of the data seems to be an issue that needs to be addressed before incorporating further mobile devices into public health. Case and colleagues evaluated mobile apps and wearable devices for tracking steps[40]. They found that the relative difference in mean step count was -6.7% to 6.2% for mobile apps and wearable devices were less accurate with relative difference ranging from -22.7% to -1.5%. Wearable devices were also found to be inaccurate for estimating total energy expenditure[41**]. Current commercially available apps for weight-management were also found to have minimal professional input[39]. Only 0.05% of over 20,000 apps on weight management had clearly used health care professionals' input in their development.

Provision of accurate information with the help of apps and wearable validated devices along with building trust between public and public health providers seems very important for the success and future of personalized health and nutrition. A recent study explored the barriers in the uptake of personalized nutrition from citizens in nine EU countries; United Kingdom, Ireland, Portugal, Poland, Norway, the Netherlands, Germany, Greece and, Spain[42]. A total of 9,381 citizens completed the study's questionnaire and reported as barriers to the uptake of personalised nutrition three factors; data protection, the eating context, and societal acceptance. Citizens also reported that they would trust as sources of information; 1) commerce and media 2) practitioners 3) government 4) family and friends.

Putting in place policy or legislation that would protect consumers/patients from potentially hazardous information included in apps and websites along with encouraging scientists who have previously developed and tested an eHealth/mHealth intervention in a randomized controlled environment to make these widely available could be a step towards upscaling eHealth/mHealth.

Reasons behind the success of the eHealth/mHealth interventions are not clear. Retention of participants which is a very common problem with studies on diet and body weight, especially with weight-loss studies[43] seems to be less of an issue in the eHealth/mHealth studies. The eHealth/mHealth studies included in this review all had relatively low attrition rates ranging from 0% in the study by Wharton and colleagues to 53% in the study by Duncan and colleagues. Better adherence to eHealth intervention was also found in a recent systematic review[44]. Young age has been previously reported as a strong predictor of attrition in studies[45,46,47]. Most of the studies included in this review had younger participants and those had the lower attrition rates. eHealth/mHealth interventions seem to be equally effective and following similar attrition rates even when the participants were of older age. Seven studies included in this review involved participants with a mean age >45 years, each of which were successful in their goals of weight-gain prevention, weight-loss or improvements in dietary habits. In the study by Spring and colleagues[20], a weight loss intervention utilizing a PDA involving 34 older adults, with a mean age of 57.7 (SD=13.5) years, was successfully implemented. Ahn and colleagues[23] observed positive changes in diabetic patients' dietary habits mean age=50.5 (SD=17.1) years, following the implementation of an Android based mobile application.

The importance of using a theory in the designing process of an intervention has been highlighted in the past by a number of studies[48,49]. There are numerous behavioural theories that may assist with behavior change. Behavioural theory is important to understand why people act in certain ways, how and why they engage with health[50]. Use of a theory can help to ensure that potential barriers to behavior change could be addressed from the time that the intervention is conceived, developed and piloted. Of the 15 studies included in this review which explicitly referenced the consideration of health behavior theories in intervention development, each was successful in the outcome of either weight-gain prevention, weight-loss and improvements in dietary habits. This is in agreeance with previous studies utilizing health behavior theories in behavior change interventions delivered by mobile devices across a range of behaviors from physical activity to smoking cessation[51,,52]. However, there is also a concern about traditional health behavior models and whether they will continue to remain relevant as eHealth and mHealth interventions become more adaptive and interactive as technology advances[53].

As all the studies included in this review were conducted in high-income countries and mostly with well-educated and high socio-economic class participants, more research is needed in middle and low income countries and with participants from more varied socioeconomic backgrounds. Interventions should also explicitly identify how varying aspects of an intervention fit with components of the Ottawa Charter in order to reduce inequalities[54]. Developing an intervention that fits with the varying Ottawa Charter components can be easily achieved for example, creating Supportive Environments can be supported by online interventions by adding, and encouraging the use of, an online forum where users can share experiences and provide support to one another.

Limitations

As with every systematic review, there might be a publication bias stemming especially from small randomized trials showing positive results[55]. Besides the 22 studies included in this review, 97 more studies were found to be exploring the research question of this review but followed different research design to a randomized controlled trial. Having had included these studies and searching grey literature for eligible studies could have any reduced any possible publication bias[56]. Considering both the constant and dynamic change in devices and technology in this field along with the lag between intervention development, evaluation, and eventual publication, the articles reviewed in this study may not accurately reflect the current status of eLearning and mHealth interventions at this moment in time.

Conclusion

This systematic review revealed a wide range of interventions using a variety of eHealth/mHealth technologies. The majority of the eHealth/mHealth interventions were successful in preventing weight gain, reducing body weight and improving dietary habits in a wide range of participants. Efforts to upscale the use of eHeath/mHealth in the clinical and public health field should be the next step given its potential for reaching large segments of the population in need for intervention. The issue of containing public concerns in terms of confidentiality, accuracy of information and validation of devices should be prioritized. Interventions tested in a randomized controlled environment should get support to make their materials widely available suitable for a variety of mobile devices and functionalities.

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***Of Importance**

****Of significant Importance**

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Figure 1: PRISMA Flow Diagram

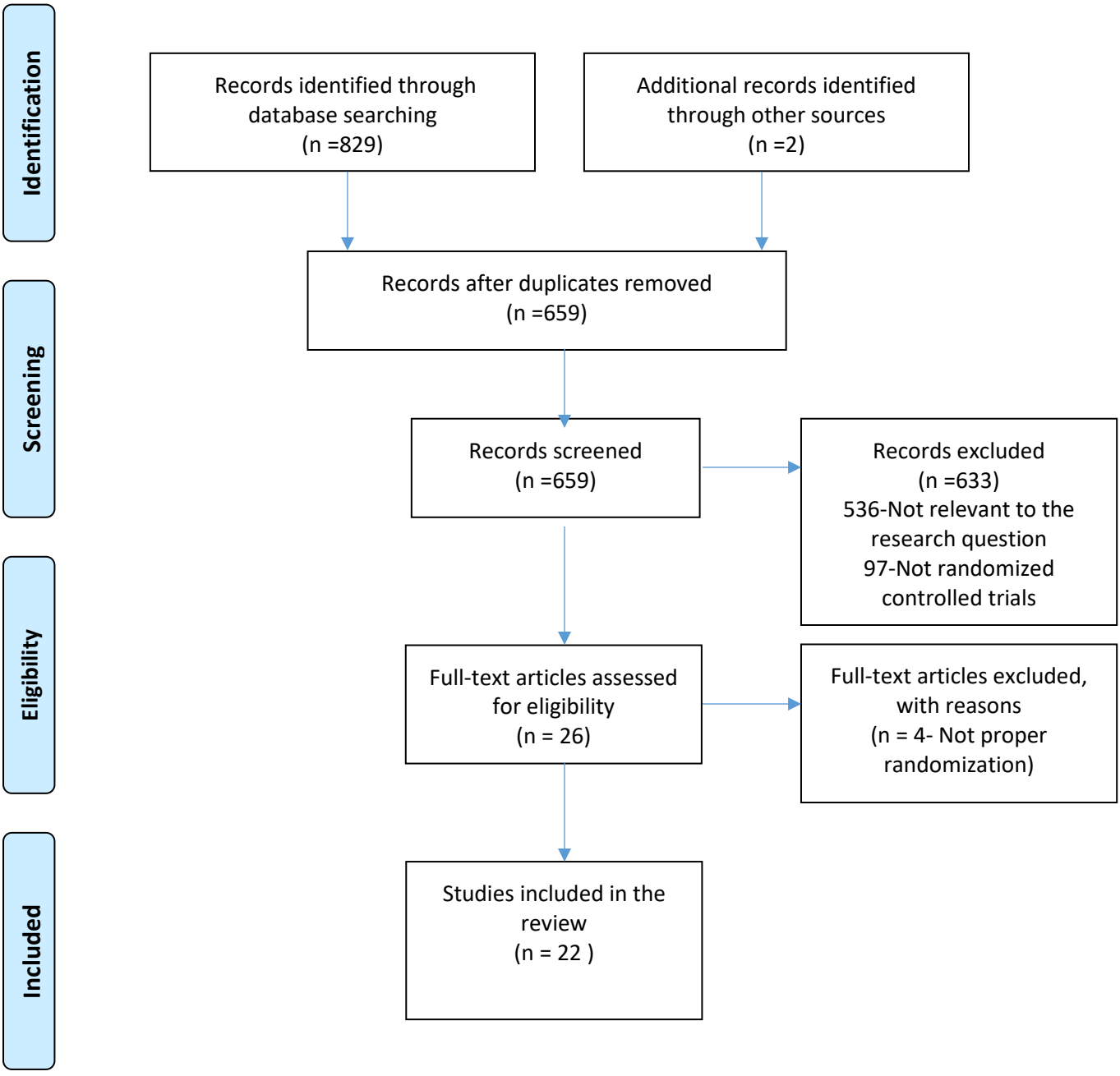

Table 1: Main characteristics, description, and quality of studies with primary outcome weight-gain prevention

Citation-Year	Population and Sample Size	Intervention	Technology used	Result	Study Duration	Study Quality*
Allman Farinelli et al 2016	18-35 years old Intervention Group=125 Control Group=125	3 phonecalls, 6 texts, 6 emails and access to a website for 6 months after intervention	Website, SMS, mobile apps, emails	Intervention Group=-3.7kg Control Group=-0.80kg	3 months and 6 months follow-up	High
Partridge et al 2015	18-35 years old Intervention Group=110 Control Group=104	8 weekly text messages, 5 phone calls	Mobile phone app and SMS	Intervention Group =2.2 kg Control Group=-0.2kg	3 months	high
Lombard et al 2010	Women with a child in elementary school Intervention Group=127 Control Group=123	4 one-hour interactive group sessions about behaviour change strategies, group discussions, and monthly support text messages	SMS	Intervention group=-0.2kg Control Group= +0.83kg	12 months	high
Nikolaou et al 2015	18-24 years old Intervention Group 1=1,810 Intervention Group 2=2,057 Control Group=2,134	19 Weekly messages tailored to participants, season and current affairs posted on Moodle. Email sent each week with the headline of the week's topic	Moodle, website, emails	Intervention 1 group=-1.0kg Intervention 2 group=-1.35kg Control Group=+2.0kg	9 months	High

*Quality was assessed with the Cochrane collaboration GRADE tool.

Table 2: Main characteristics, description, and quality of studies with primary outcome weight-loss

Citation-Year	Population and Sample Size	Intervention	Technology used	Result	Study Duration	Study Quality
Brindal et al. 2013	Overweight women 19-63 years old Intervention Group = 28 Control Group = 30	Information, food intake recording, rewards for positive behaviour, prompts to interact and self-monitoring weight and diet	Mobile application	Intervention Group=3.8% weight-loss Control Group=2.5% weight-loss	2 months	Moderate
Hebden et al. 2014	18-35 years old Intervention Group:26 Control Group:25	A printed diet booklet with instructions prepared by a dietitian. Intervention group also received text messages (four per week), e-mails (four per week), and had access to smartphone applications and Internet forums.	SMS, emails, mobile applications and internet forums	Intervention group=-1.61kg Control group=-1.41kg	3 months	Moderate
Lin et al. 2015	African-American with BMI>27kg/m^2 Intervention Group: 63 Control Group: 61	Standard Care and SMS	SMS	Intervention Group=-5.2kg at 6 months Control Group= -1.8kg at 6 months	12 months	High
Oh et al 2015	Obese patients with metabolic syndrome	Remote monitoring, Uhealth care service,	Mobile Application	Intervention Group=-2.21kg	6 months	High

Spring BMJ et al 2013	Overweight and obese adults mean age 57.7 years Intervention Group=34 Control Group=35	Training session, PDA for recording food intake, weight, and physical activity. Biweekly sessions on nutrition, physical activity, behaviour change	PDA	Intervention group lost 3.9kg more compared to control group	12 months	High
Steinberg et al 2013	Overweight women 25-50 years old Intervention Group=26 Control Group=24	Daily text messages for self-monitoring tailored behavioral goals along with brief feedback and tips	SMS and emails	Intervention Group=-1.27kg Control group=+1.14kg	6 months	High
Turner-McGrievy et al 2011	Overweight/obese adults 18-60 years Intervention Group=49 Control Group=47	Podcast+mobile group: received 2 podcasts per week for 3 months and 2 minipodcasts per week for months 3-6, a diet and physical activity monitoring apps on their mobile device and interaction with other participants and study counselors on Twitter	Mobile application and Social Media	Intervention Group=-2.7% Control Group=-2.7%	6 months	Moderate
Wharton et al 2014	Overweight/obese Adults 18-65 years old Intervention Group 1=19 Intervention Group 2=18 Control Group=20	Intervention 1: Diet-tracking and recording using the 'Lose It!' mobile app Intervention 2: diet recording using smartphones' memo function Control: diet recording using paper and pencil	Mobile Application	Intervention 1=-3.5lb Intervention 2= -6.5lb Control group=-4.4lb	2 months	Low

*Quality was assessed with the Cochrane collaboration GRADE tool.

Table 3: Main characteristics, description, and quality of studies with primary outcome dietary behavior/Health promotion

Citation-Year	Population and Sample Size	Intervention	Technology used	Result	Study Duration	Study Quality
Ahn et al. 2016	Patients with Diabetes Group = 14 (mean age 50.5) Control Group = 12 (mean age 49.7)	Record of diet intake with photos and alarm to remind of data input	Android Mobile App linked to a web-based program	Intervention group = increased healthful dietary behavior and dietary attitude Control group = increased intake of calcium and sodium	1 month	Low
Ambeba et al. 2015	Obese adults 18-59 years old Intervention Group= 70 Control group= 140	Weight-loss programme and tailored feedback through PDA	PDA	Intervention group: Energy intake=-23.4%, Ssaturated fat= -9.3% Control group Energy intake=-14.1%, Saturated fat=-3.4%	24 months	Moderate
Blackburne et al 2016	Overweight (mean BMI 29.5) people 19-61 Intervention Group = 29 Control Group = 29	10 approximately one-minute games per day for 14 consecutive days to increase healthy food consumption, reduce unhealthy eating, result in psychological and neurological changes (Inhibitory	Mobile App	Intervention group = improved Inhibitory control performance with increased training	2 weeks, then pause for 4.5 weeks, 2 weeks	Moderate

Duncan et al 2014	Male adults 35-54 years old Intervention Group = 205 Control Group = 96	IT-based intervention Improve PA, dietary behaviour, health literacy	Website and mobile device	No significant difference in dietary behaviour between groups	9 months	Moderate
Kerr et al. 2016	Adults without serious illnesses between 18-30 years Intervention Group 1= 82 Intervention group 2=83 Control Group = 82	Intervention 1=Feedback and weekly text messages Intervention 2=Feedback only	SMS, mobile app	No significant changes in food group serves in any of the groups	6 months	High
Mummah et al 2016	Overweight adults without serious illnesses between 18-50 years Intervention Group = 8 Control Group = 9	Set goals for and log vegetables consumption in mobile app	iOS app	Intervention Group = greater consumption of vegetables 13.5 servings Control Group =3.9 servings	12 weeks	Moderate
Safran et al 2015	Healthy adults mean age 47.9 years Intervention Group = 56 Control Group =29	Introductory meeting, personal goal setting and feedback, web-based app	Web-based app	Intervention Group = diet quality increased from 67 to 71 ($p < .001$) Control Group = no change in diet quality	14 weeks	High
Spring BK et al 2012	200 participants between 21-60 years 4 arms: Intervention Group1 = increase fruit and vegetables intake and PA Intervention Group 2 = decrease fat	PDA for recording and self-regulating targeted behaviours	PDA	All groups: daily fruit/ vegetable intake increased from 1.2 servings to 5.5 servings, saturated fat intake decreased from 12% to 9.5% of consumed calories	3 week treatment, 5 month follow-up	Moderate